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DIVING COMPUTER OPERATIONAL ENVELOPE PROVING PROTOCOL PHASE I. --ETC(U)
JUL 79 M D KOONER , B A RIDGEWELL

UNCLASSIFIED DCIEM-TC-79C33 NL

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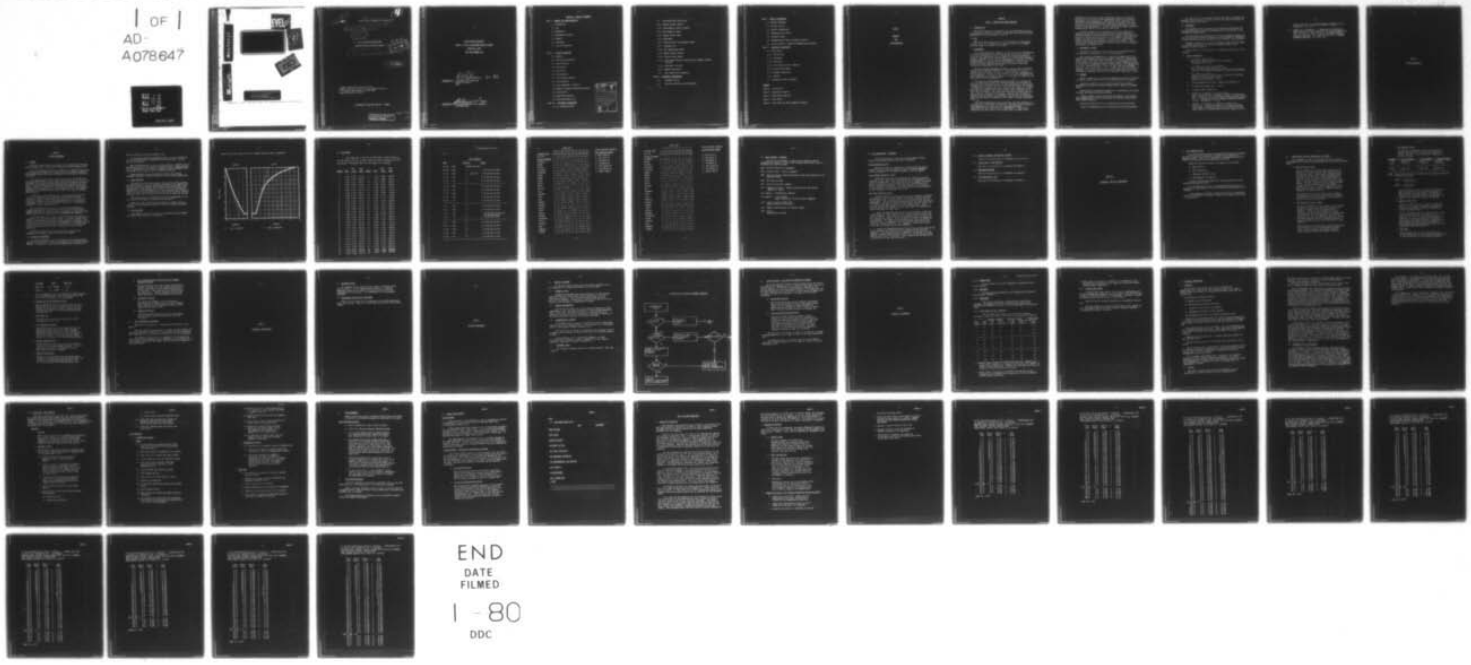

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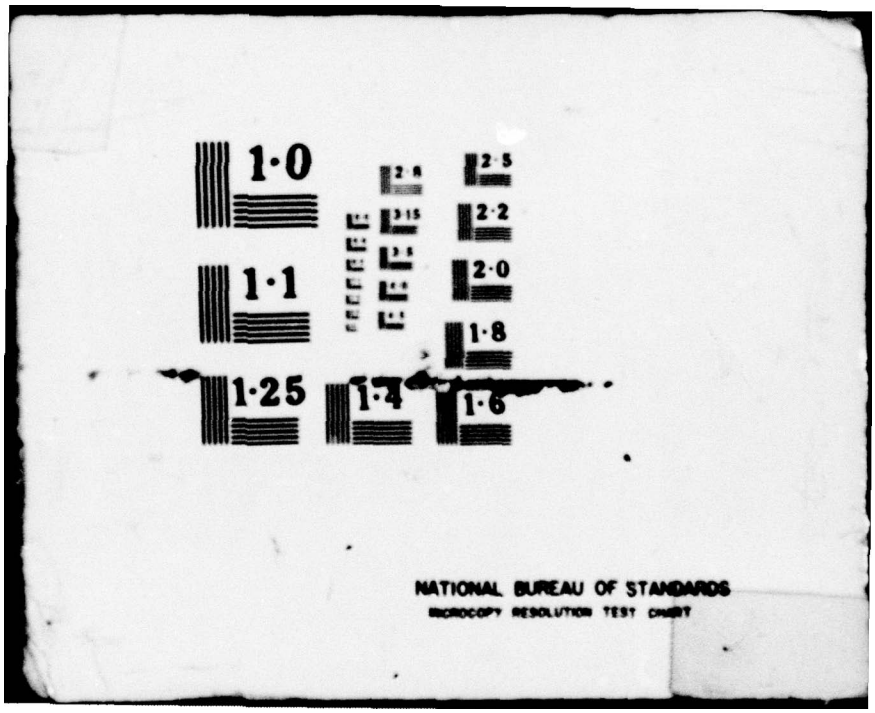
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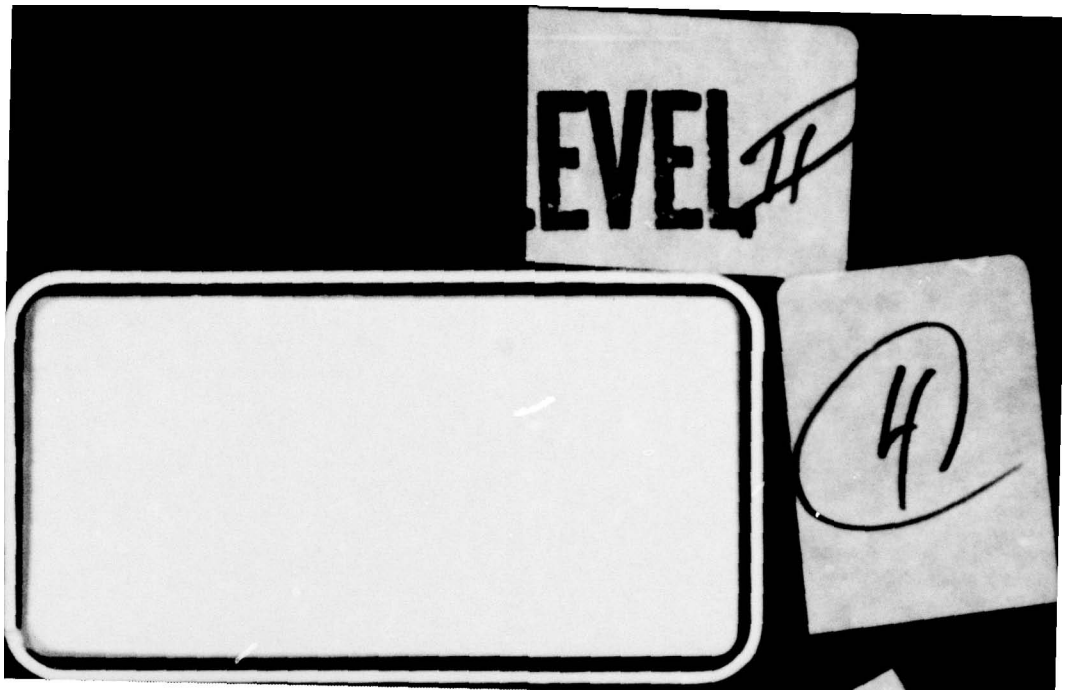
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(6) DIVING COMPUTER OPERATIONAL ENVELOPE PROVING PROTOCOL PHASE I.

XDC-2 Validation Dives
0-54 msw June/July 1979.

(10) M.D./Kooner
B.A./Ridgewell

Canadian Experimental Diving Division
Defence and Civil Institute of Environmental Medicine
1133 Sheppard Avenue West, P.O. Box 2000
Downsview, Ontario M3M 3B9

DEPARTMENT OF NATIONAL DEFENCE - CANADA

406 996

DCIEM DIVING DIVISION

PHASE I - XDC-2 VALIDATION DIVES 0-54 MSW

JUNE/JULY, 1979

DDF TEST NUMBER 79-2

SUBMITTED BY: Lieutenant M.D. Kooner RN
Executive Officer
CEDD

APPROVED BY: Lieutenant-Commander B.A. Ridgewell
Director Diving

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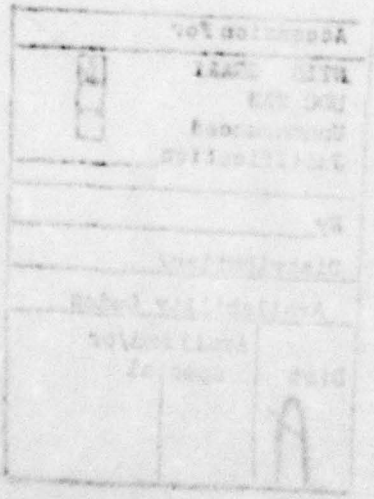


PART I

GENERAL

AND

ADMINISTRATION

PROTOCOL

PART I - GENERAL AND ADMINISTRATION

1.1 INTRODUCTION

The Diving Division in conjunction with the Biosciences Division will carry out a series of air dives in the Deep Diving Facility, DCIEM commencing 19 Jun and concluding 13 Jul 79.

1.2 AIM

The aim of this series of dives is to determine the operational envelope of the XDC-2 Decompression Computer using air to a maximum simulated depth of 54 metres of sea water.

1.3 BACKGROUND

The DCIEM decompression computer is used for the safe decompression of divers by monitoring the actual depth-time history of a dive and calculating and displaying the safe depth for optimum decompression. In the past, the computer was used successfully in the form of a pneumatic analogue computer. With the recent developments in electronics, it has become possible to replace such analogue computers with miniature digital electronic computers which monitor the diver's depth and calculate the safe depth in real-time.

The XDC-2 Digital Decompression Monitor was designed for DCIEM on contract by CTF Systems Incorporated. The advantage of a digital computer such as the XDC-2 is that it requires minimal calibration and less maintenance. Because the safe depth is calculated mathematically and is presented on a digital display, it is possible to follow the safe depth exactly during decompression.

The objective of the present series of dives is to evaluate the XDC-2 for operational diving, to determine whether the safe depth as displayed can be followed exactly for safe decompression, and to define the operational limits for its use. The basic dive profile is descent at 18 metres of seawater (msw) per minute to depth, remaining at that depth for the required time; initial ascent is at 18 msw/min. to the calculated safe depth, continuous ascent following the safe depth to 3 msw, a stop at 3 msw until the computer indicates that surfacing is possible, and then ascent to the surface. See Article 6.1 and Annex D and E for more detailed information with respect to ascent and descent times.

The DCIEM decompression calculation model has been determined by carrying out a large number of man-dives. The model itself consists of four compartments in series with the same depth-dependent supersaturation ratio applied to all compartments. Under certain conditions, for deep dives or long bottom times, the model gives

decompression tables which become inordinately long at the shallow depths when the third and fourth compartments become the controlling compartments for decompression. The maximum bottom times which are intended to define the operational limits for the present dive series have been selected so that the third and fourth compartments are not controlling the decompression. Several bottom times leading toward the maximum bottom time will be tested for each depth.

In order to assist in the evaluation of the dive profiles as generated by the XDC-2 and to determine their relative safety or to determine whether any modifications need to be made in the future, the divers will be monitored for bubbles in the pulmonary artery with the Doppler Ultrasonic Bubble Detector. Dry divers will be monitored periodically during the decompression phase in the chamber. On the surface after decompression, both dry and wet divers will be monitored periodically for several hours.

1.4 PROGRAMME OF EVENTS

This series of dives will be carried out in accordance with the Dive Schedule as published in Part II of the Protocol.

The long-term programme will be finalized on completion of this series of dives which for recording purposes, should be categorized as "Phase I XDC-2 Validation Dives 0-54 msw". It follows that the long-term objective is to ensure that the diving military community be able to use the XDC-2 Decompression Monitor model safely to its maximum range which will include mixed gas diving to 90 MSW. The total programme could well last several years. It is intended that the XDC-2 models be issued to the Fleet Diving Units prior to the completion of the total programme in accordance with guidelines and proved limitations to date.

1.5 SUPPORT

Medical support will be provided throughout this series of dives by the Diving Division Medical Officer and CFB Toronto MIR if required.

Scientific support will be provided by the Diving Division, Biosciences Division and external support from Mr. Masurel of CERTSM, France.

Operational and Engineering support will be provided by the Diving Division and Technical Services Division.

Logistic support will be provided by CFB Toronto in the form of Base transportation, rations and quarters for subjects and box meals where deemed necessary.

Post-dive bends watch will be provided by the Diving Division.

Post-dive documentation will be provided by the Diving Division.

Dive subjects will be provided by DCIEM Diver Pool, CFB Toronto and outlying districts pool and a special team of four subjects courtesy of the Fleet Diving Unit Pacific.

1.6 PROCEDURES

All procedures will be carried out in accordance with normal safe diving practices and scientific experiments will be carried out within the limits of human ethics.

The Standing Operating Procedures are to be followed throughout the exercise and whenever humanly possible, strictly adhered to. Amendments to the protocol may only be authorized by the Director, Diving Division.

Emergency Procedures and relevant equipment/system check-off sheets for the safe operation of the DDF will be made available at the respective control consoles.

Diving SOP's will be carried out in accordance with Part II of the protocol.

1.7 LIST OF REFERENCES

1. R.Y. Nishi, DCIEM Toronto.
Real Time Decompression Monitoring by Computers
DCIEM Report No. 78-X-27

2. L.A. Kuehn, R.Y. Nishi, DCIEM Toronto
Use of Decompression Computers in Diving
Reprinted from Chemistry and Physics of Aqueous Gas Solutions

3. R.Y. Nishi, L.V. Allin
Conversion Tables for Oxygen Partial Pressure to Percentage Oxygen at Various Depths (in Bars)
DCIEM Technical Report No. 79-X-2.

4. DCIEM Decompression Profiles, compiled by DCIEM Oct 77.

5. CTF Operations Manual XDC-2 - Jun 78.

6. CTF Manual DDL-1 MA109-0179.

7. Kisman, K.E., Masurel, G. and R. Guillerm.
Bubble Evaluation Code for Doppler Ultrasonic Decompression Data. Annual meeting of the Undersea Medical Society, Seattle Apr. 78. Abstract published in Undersea Biomedical Research 5, No. 1 (Supplement), 28, 1978.

8. Masurel, G., Gardette, B., Comet, M., Kisman, K.E., Guillerm, R. Ultrasonic Detection of Circulating Bubbles during JANUS IV excursion dives at sea to 460 and 501 MSW. Annual meeting of Undersea Medical Society, Seattle, Apr 78.

Abstract published in Undersea Biomedical Research 5, No. 1 (Supplement), 29, 1978.

9. Kisman, K.E. and Masurel, G. Comparison of Computerized Bubble Grading with Aural Grading of Ultrasonic Decompression Data from Divers. Annual meeting of the Undersea Medical Society, Miami, May, 1979. Abstract published in Undersea Biomedical Research 6 (in press) 1979.

PART II

DIVING OPERATIONS

PART II

DIVING OPERATIONS

2.1 GENERAL

All dives for this XDC-2 test series will be conducted in the Deep Diving Facility (DDF) utilizing the transfer and diving chambers only.

The diving personnel resources of CEDD will be augmented during the trial period by four members of Fleet Diving Unit (Pacific), members of CFB Toronto's Ships Diver Pool and members of DCIEM qualified to Ships Diver level.

All divers available to perform as subjects will be divided into two diving teams, Teams A and B. Team A will consist of six divers plus one spare diver who will be permanently delegated as members of Team A. Team A will dive every other day throughout the duration of the test series. Team B will comprise six divers and one spare drawn from the remaining dive personnel as their availability dictates. Thus Team B's composition will vary from day to day. Team B will dive on alternate days to Team A.

A total of six diving subjects will be pressurized during each dive, two of whom shall be wet working divers (under light work conditions) dressed in KMB-9 masks with standard wet suits while the other four subjects will be dry non-working divers in a dry diving environment. Two of the dry non-working divers will be delegated as tenders for the wet working divers.

The dive profiles will consist of three simulated depths of seawater combined with three different bottom times for each depth. Decompression from all dives will be in accordance with the safe ascent depths generated by the monitoring XDC-2 Decompression Computers.

During these XDC-2 dive trials a parallel monitoring study will be conducted by Dr. Ken Kisman (DCIEM) and Mr. G. Masurel (CERTSM Toulon, France) utilizing doppler ultrasonic bubble detection equipment. Dry diving subjects will be monitored from commencement of decompression for a total of six hours while the wet diving subjects will be monitored after surfacing from the dive until conclusion of the dry diver's monitoring.

The DDF facilities will also be utilized to carry out any recompression treatments resulting from diving ailments.

2.2 DIVING POOL PERSONNEL

All divers available in the diving pool have been scheduled for specific dives on specific dates in accordance with the Diving Subjects Schedule. Included is a diver position legend which indicates the

subject's position during each specific dive.

On the days personnel are required to dive, it will be necessary for all concerned divers to conform to the Daily Routine - Diving Subjects as outlined.

When delegated as one of the wet diving subjects, personnel will be required to be dressed in a diver's standard wet suit. Those personnel not in possession of a wet suit are to make suitable arrangements with the Diving Division prior to their scheduled diving day.

Should personnel not be available to fulfill their diving commitment they are to contact CWO Larsen at the earliest opportunity.

2.3 DIVER TRAINING

To ensure that all diving tenders, dry subjects and wet subjects are totally familiar with the operating procedures of the KMB-9 diving mask and the diving equipment configuration requirements when diving this equipment in the Deep Diving Facility, it will be necessary to implement a training programme for all diving subjects not on staff at CEDD. This will include instruction on the DDF pertaining to internal equipment layout and guidelines for subjects while inhabiting the DDF.

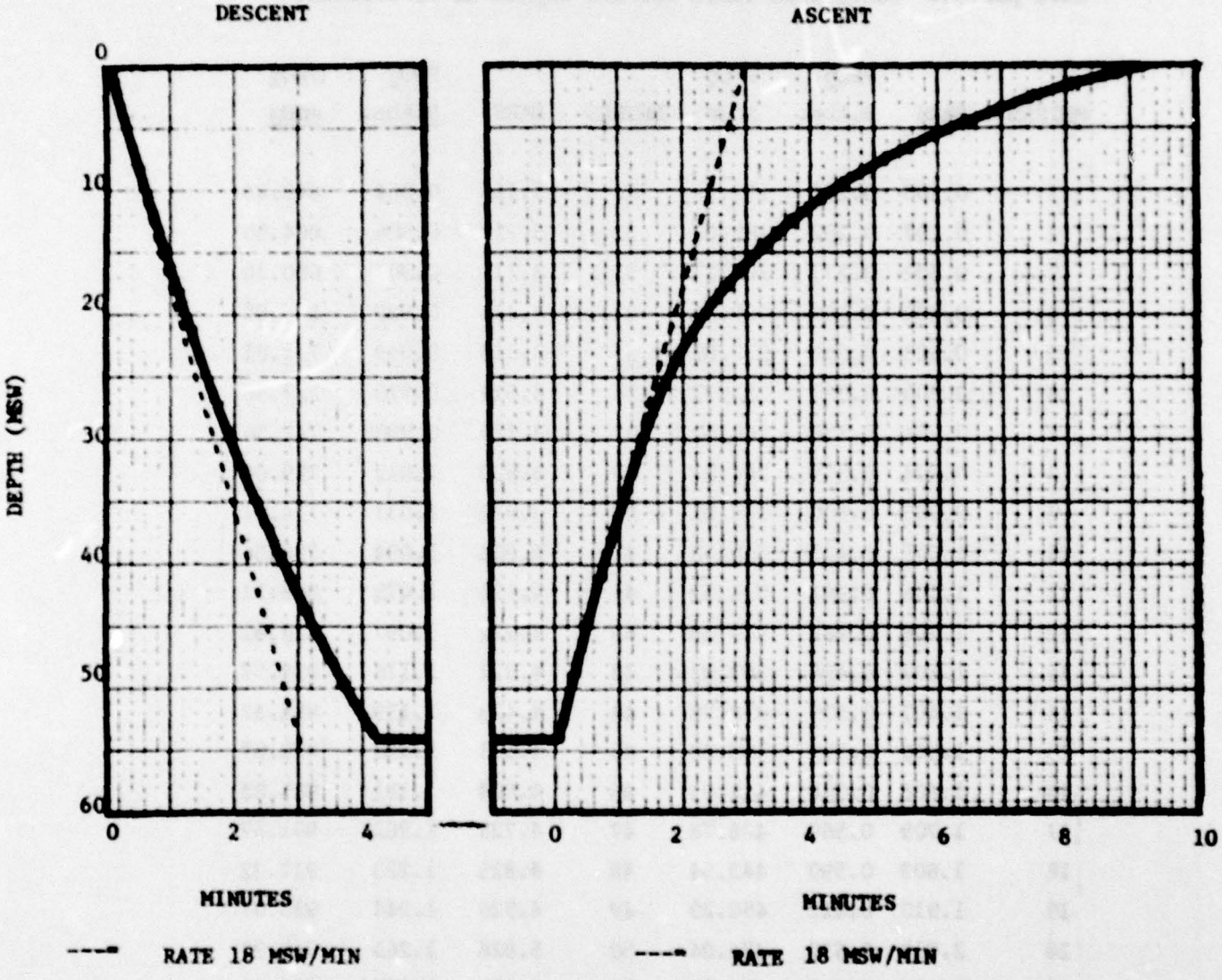
This training will be conducted prior to the commencement of the XDC-2 trials as arranged and scheduled by CEDD staff.

There will also be some training required to instruct diving subjects in the procedures required for using the doppler monitoring equipment.

2.4 DIVE PROFILES

Dive profiles will be carried out in accordance with the descent and ascent graph, Article 6.1 and Annex E.

DESCENT AND ASCENT PROFILES FOR DIVE CHAMBER/TRANSFER SPHERE COMBINATION



2.5 PO_2 CURVES

This graph will be held by the DDF Staff in the vicinity of the DDF console, and will be made readily available throughout the XDC-2 dive period. Conversion Table for 21% oxygen is as follows:

METRES	BARS	PPO_2 B.Abs.	PPO_2 mmHg	METRES	BARS	PPO_2 B.Abs.	PPO_2 mmHg
1	0.100	0.231	173.26	31	3.116	0.864	648.05
2	0.201	0.252	189.02	32	3.217	0.886	664.55
3	0.302	0.273	204.77	33	3.317	0.907	680.30
4	0.402	0.294	220.52	34	3.418	0.928	696.06
5	0.503	0.316	237.02	35	3.518	0.949	711.81
6	0.603	0.337	252.77	36	3.619	0.970	727.56
7	0.704	0.358	268.52	37	3.719	0.990	742.56
8	0.804	0.379	284.27	38	3.820	1.012	759.06
9	0.905	0.400	300.02	39	3.920	1.033	774.81
10	1.005	0.421	315.78	40	4.021	1.054	790.56
11	1.106	0.442	331.53	41	4.121	1.075	806.31
12	1.206	0.463	347.28	42	4.222	1.097	822.82
13	1.307	0.484	363.03	43	4.322	1.118	838.57
14	1.407	0.505	378.78	44	4.423	1.139	854.32
15	1.508	0.527	395.28	45	4.523	1.160	870.07
16	1.608	0.548	411.03	46	4.624	1.181	885.82
17	1.709	0.569	426.78	47	4.725	1.202	901.57
18	1.809	0.590	442.54	48	4.825	1.223	917.32
19	1.910	0.611	458.29	49	4.926	1.244	933.07
20	2.010	0.632	474.04	50	5.026	1.265	948.83
21	2.111	0.643	489.79	51	5.127	1.287	965.33
22	2.211	0.674	505.54	52	5.227	1.308	981.08
23	2.312	0.696	522.04	53	5.328	1.329	996.83
24	2.413	0.717	537.80	54	5.428	1.350	1012.58
25	2.513	0.738	553.54	55	5.529	1.371	1028.33
26	2.614	0.759	569.30	56	5.629	1.392	1044.08
27	2.714	0.780	585.05	57	5.730	1.413	1059.83
28	2.815	0.801	600.80	58	5.830	1.434	1075.59
29	2.915	0.822	616.55	59	5.931	1.456	1092.09
30	3.016	0.843	632.30	60	6.031	1.477	1107.84

2.6

DIVE SCHEDULE

DATE	DIVE DAY		SERIAL
18 Jun - Mon	Preparation Day		
19 Jun - Tue	1		C (36 msw for 50 min)
20 Jun - Wed	2	Cancelled	C (36 msw for 50 min)
21 Jun - Thu	3		B (36 msw for 40 min)
22 Jun - Fri	4		B (36 msw for 40 min)
25 Jun - Mon	5		A (36 msw for 30 min)
26 Jun - Tue	6		A (36 msw for 30 min)
27 Jun - Wed	7		D (45 msw for 20 min)
28 Jun - Thu	8		F (45 msw for 30 min)
29 Jun - Fri	9		E (45 msw for 25 min)
3 Jul - Tue	10		E (45 msw for 25 min)
4 Jul - Wed	11		F (45 msw for 30 min)
5 Jul - Thu	12		C (36 msw for 50 min on O_2 for decompression)
6 Jul - Fri	13		G (54 msw for 15 min)
9 Jul - Mon	14		H (54 msw for 20 min)
10 Jul - Tue	15		H (54 msw for 20 min)
11 Jul - Wed	16		J (54 msw for 25 min)
12 Jul - Thu	17		J (54 msw for 25 min)
13 Jul - Fri	18		G (54 msw for 15 min)

2.7

JUNE, 1979

	M	T	W	T	F	M	T	W	T	F
CALENDAR DATE	18	19	20	21	22	25	26	27	28	29
DIVE DAY		1	2	3	4	5	6	7	8	9
DIVING PERSONNEL										
RIDGEWELL								C		
KOONER				A						
MITCHELL						C				A
OUELLETTE			B		C		D		E	
FULLERTON								E		
LARSEN		C				A				E
MANTEL				C				A		
JAGGER			S		S		S		S	
REGIER		A				E				C
NECPAL										
MACLEAN		F		B						S
PAUL						S		S		F
MATTHEWS			C		F		E		B	
LEGAY			D		E		F		A	
FORD			E		B		A		D	
SABOURIN			F		A		B		C	
GOULARD										
LESSARD			A		D		C		F	
CLARK		S				B				
PORLIER		B				D		F		
EASTMAN				S		F				
SUTHERLAND				E						D
KEELER		E		D						
SKAALRUD										
NOLK		D						B		
MEDHURST				F				D		B
CRYMBLE										

DIVING SUBJECTS SCHEDULE

Dive Position Legend

A - Wet Diver #1

B - Wet Diver #2

C - Attendant #1

D - Attendant #2

E - Dry Subject #1

F - Dry Subject #2

S - Spare Subject

2.7

JULY, 1979

	T	W	T	F	M	T	W	T	F
CALENDAR DATE	3	4	5	6	9	10	11	12	13
DIVE DAY	10	11	12	13	14	15	16	17	18
Diving Personnel									
RIDGEWELL		A							
KOONER				C				D	
MITCHELL						E			
OUELLETTE	F		A		B		C		D
FULLERTON		D		S					
LARSEN						B			
MANTEL		C				F			
JAGGER	S		S		S		S		S
REGIER				B				E	
NECPAL									
MACLEAN		E		A					
PAUL						S		A	
MATTHEWS	A		D		C		F		E
LEGAY	B		C		D		E		F
FORD	C		F		E		B		A
SABOURIN	D		E		F		A		B
GOULARD									
LESSARD	E		B		A		D		C
CLARK		F				C		S	
PORLIER									
EASTMAN		S		D					
SUTHERLAND				F					
KEELER						A		F	
SKAALRUD									
NOLK				E				C	
MEDHURST		B							
CRYMBLE						D		B	

DIVING SUBJECT SCHEDULE

Dive Position Legend

A - Wet Diver #1

B - Wet Diver #2

C - Attendant #1

D - Attendant #2

E - Dry Subject #1

F - Dry Subject #2

S - Spare Subject

2.8 DAILY ROUTINE - SUBJECTS

The following programme is based on the assumption that no decompression sickness or other diving ailments occur either during or following the scheduled dives.

0800 - Pre-dive Physician's Assessment

0815 - Pre-dive Check - Divers' Equipment

0830 - Pre-dive Doppler reference monitoring (wet diving subjects to be monitored first)

0900 - Wet subjects dress

0915 - Pre-dive check-outs commence

0930 - Compression begins - (Doppler monitoring for dry subjects commences at depth).

1030 (Approx) - Decompression commences

1145 (Approx) - Divers surface
Doppler monitoring for wet subjects commences

1200 - Lunch in Divers' Lounge area
Doppler monitoring to continue

1530 - Doppler monitoring for all subjects ceases

1600 - Secure
Bends Watch activated.

2.9 DIVE PROCEDURES - SUBJECTS

As stated previously, there will be three types of diving subjects for evaluation during each dive as follows:

Diving Subjects E and F

These two divers will normally be at rest during the entire length of the dive and will spend their time (unless an emergency dictates otherwise) in the transfer chamber of the DDF complex.

Diving Tender Subjects C and D

These two divers will be responsible for tending the two wet (working) divers. One of the diving tenders will be delegated as the inside dive supervisor. Their function will be to support the working divers in dressing, tending of umbilicals and also monitoring the divers' communication network. The tender subjects will usually be in the vertical or standing position and located in the wet chamber of the DDF throughout the duration of the dive.

Wet Diver Subjects A and B

The wet (working) diving subjects are to be dressed in standard foam neoprene diver wet suits complete with KMB-9 breathing apparatus for the entire dive. Subjects are to be fully dressed prior to dive commencement. During the pressurization phase of the dive, the subjects will stand in the water in the wet chamber forward of the barrier but will not don the KMB-9 apparatus until "reaching bottom". After reaching bottom, both subjects will don their KMB's and immerse their entire body below the water level.

During the remaining part of the dive one diver at a time will proceed under the barrier and carry out a work simulation task on the diving ergometer. Work loads will be relatively light (50 watts) and will last for six minutes. While the one diver subject is working on the ergometer, the second will stay immersed and act as the safety or stand-by diver. On completion of each six minute work period, the divers will rotate positions. This sequence of events will continue until the dive bottom time has been completed.

2. During the decompression phase of the dives, the dry subjects and tender subjects will be monitored using doppler bubble detection equipment. This monitoring will be conducted in accordance with the Doppler Ultrasonic Monitoring Outline and will include the wet diving subjects after the dive surfaces. After surfacing the monitoring will be carried out in the CEDD lounge area.

2.10 DOPPLER ULTRASONIC MONITORING OUTLINE

This will be carried out in accordance with Article 6.2.

2.11 DIVING SOP'S - WET SUBJECTS

This will be carried out in accordance with Annex A.

2.12 BEND WATCH ROUTINE

This will be carried out in accordance with Annex B.

2.13 DUTY BENDS WATCH LIST

This will be carried out in accordance with Annex C.

PART III

HYPERBARIC FACILITY OPERATIONS

3.1 DDF OPERATING STAFF

The primary operating team of the Deep Diving Facility throughout the XDC-2 trials will be composed of members from the Hyperbaric Operations Group. They will be responsible to the Operations Officer, CEDD for the safe and efficient operation of the DDF.

Operating positions required to be manned are as follows:

a. Watch Officer;

b. Chief Controller;

c. Assistant Controller; and

d. Environmental Loop Monitor.

Technical engineering support will be made available from the Hyperbaric Engineering staff.

As the opportunity arises, the primary operating team will be augmented by other members of the Diving Division as authorized by the Director.

A DDF Operations Personnel Delegation List will be promulgated indicating assignment of personnel to specific DDF operating positions on a daily basis.

3.2 DEEP DIVING FACILITY OPERATIONAL FACILITIES

To accommodate the XDC-2 operational evaluation protocol requirements, the following DDF sub-systems will be on line as defined below:

1. Manual Control Console

The dive chamber and transfer sphere sections of the console will be manned and on line using air as the pressurization gas. Primary means of communication with the dry subjects will be the PA system and for the divers, the VOX system. The primary means of determining depth and rate of travel will be via the XDC-2 in the metric mode, verified by the Hesse Gauge (BARS). The XDC-2 computers will be mounted in such a manner that they are visible to the console operator as well as to the XDC-2 computer recorders. Four remote TV monitors for both chambers are to be mounted on the manual console.

The responsibilities of the Manual Control Console operators are to follow the respective dive profiles as determined by the Watch Officer and to record the events in the Dive Log provided.

2. Environmental Control Console

The main environmental control console will be manned to monitor, maintain and log partial pressures of oxygen and carbon dioxide as required by the protocol. In view of the fact that air is the pressurization and breathing media to a maximum depth of 54 MSW, and that the respective loops will be scrubbing CO_2, then the maximum PO_2 will be 1.34 ATA. The oxygen controllers will be operated manually in order to maintain the PO_2 level equivalent to air as required.

Relative humidity will only be a consideration during the treatment of a severe decompression sickness case. In this instance, the relative humidity ideally should be maintained between 50-70% R.H.

4. Environmental Loops

The specific environmental loop will be on line to maintain the required levels of carbon dioxide and relative humidity. In this regard the loops will be packed as follows:

CANISTER	LIVING CHAMBER	DIVE CHAMBER	TRANSFER SPHERE
1 OUTER	On-line Silica Gel	On-line Silica Gel	On-line Silica Gel
1 INNER	Soda Lime	Soda Lime	Soda Lime

NOTE: The following outer/inner baskets will be filled and ready for inserting as follows:-

Outers - 2 Silica Gels
1 Molecular Sieve

Inners - 2 Silica Gels
1 Soda Lime

The DDF Operations Staff will ensure that sufficient soda lime and silica gel are readily available to meet the XDC-2 dive requirements. The operating status and the individual canister contents will be logged by the Environment Control Unit Monitor.

4. Oxygen Control Panel

Sufficient oxygen shall be on line to satisfy the projected dive protocol requirements, taking into account the environmental loop and decompression sickness treatment needs;

The DDF Operations Staff will ensure that sufficient oxygen has been ordered to meet the XDC-2 dive requirements. This will also entail 10 bottles of oxygen on line and available at "C" Manifold in the O_2 Room. Environment Control Unit Monitor will check the Oxygen Control Panel, the status of environmental loop metabolic make-up valves, and the oxygen BIBS overbottom pressure.

5. BIBS GASES

The DDF Operational Staff will ensure that the following BIBS gases are mixed or immediately on line to the BIBS Manifolds in the respective chambers.

GAS MEDIA	DEPTH	MAX. PO_2
20/80 Air	(0 - 54 MSW)	1.34
100% O_2	(0 - 18 MSW)	2.8

The environmental control unit monitor personnel detailed will be responsible for ensuring that the correct gas is on-line in accordance with the protocol.

6. Pressurization and Equipment Panels

The DDF Operations Staff shall ensure that the air supply from the 300 ft. RCC banks is on-line at 1500-1600 psi up to the Manual Control Console, via the pressure select panel, air being the pressurization and breathing gas.

7. Instrument Air

The DDF Operations Staff shall ensure that LP/HP instrument air is on line.

8. Fire Suppression System

The DDF Operations Staff shall ensure that the fire suppression system to the Dive Chamber/Transfer Sphere and Living Chamber is on-line. During the decompression phase of the dive, attention should be paid to the respective tanks tracking the chamber depth and the maintenance of the overbottom pressure.

9. Sewage Disposal System

The DDF Operations Staff shall ensure the pressure integrity of the sewage disposal system. It will be made readily available, although the main and eqyalizing valves will be secured.

10. Potable Water System

Though it is not envisaged that the Potable Water System will be required, the DDF Operations Staff are to ensure its being immediately available and on-line, but secured at the Transfer Sphere Hull.

11. Dive Chamber/Transfer Sphere and Living Chamber Internal Fittings

The DDF Operations Staff shall ensure that the Dive Chamber is flooded up to the respective barriers and that the umbilicals for both divers/Stand-by diver are functional. BIBS masks are to be exercised with each BIBS outlet. Internal communications via the PA/VOX systems are to be tested prior to each dive.

12. Underwater Fittings

The underwater ergometer is to be fitted and continuity checks completed prior to total flooding. These items are to be co-ordinated between the DDF Operations Staff/R&D Section.

13. Doppler Monitoring

DDF Technical and biotechnical staffs are to ensure that the Doppler Monitoring System is fitted and functional.

3.3 XDC-2 MONITORING PROCEDURES

These will be carried out in accordance with Article 6.1 and Annex D.

The XDC-2 monitoring technician is to keep the Watch Officer and the Console Operators informed as to which computer is the controlling XDC-2 computer and of any necessity to change the controlling computer.

The computer technician will be responsible for informing the Watch Officer, once decompression has commenced, of any differentials of depth readouts between the DDF complex and the controlling computer's safe ascent depth.

PART IV

HYPERBARIC ENGINEERING

4.1 EQUIPMENT STATUS

The equipment status for the series of XDC-2 validation dives, known as Phase I, will be comprehensively covered in a separate memorandum issued by the Director, Diving Division prior to the commencement of the exercise. This memorandum will be prominently displayed.

4.2 ENGINEERING ROUTINES AND PROCEDURES

These will be carried out in accordance with the CEDD Engineering Orders as published. They will be made readily available at the Control Console.

PART V

MEDICAL PROCEDURES

5.1 MEDICAL DOCUMENTS

All subjects should ensure that their medical documents are in the possession of the Medical Department, Diving Division.

5.2 FITNESS TO DIVE

Subjects are reminded that these dives are of an experimental nature and that the divers should maintain themselves in as fit a condition as possible. Late nights and alcohol abuse are to be particularly condemned. A good night's rest prior to the dive will be helpful in the avoidance of decompression sickness.

5.3 MEDICAL EXAMINATIONS

All divers will receive an initial medical examination at the commencement of the experiment followed by a short cursory examination prior to each dive. Any unusual feelings or incidents should be reported to the Medical Officer immediately, regardless of whether, in the subject's opinion, they are or are *not* dive-related.

5.4 DECOMPRESSION SICKNESS

It is hoped that no incidences of DCS will occur on these dives. However, should this problem arise, it will be dealt with in accordance with the flow diagram treatment protocol (5.6).

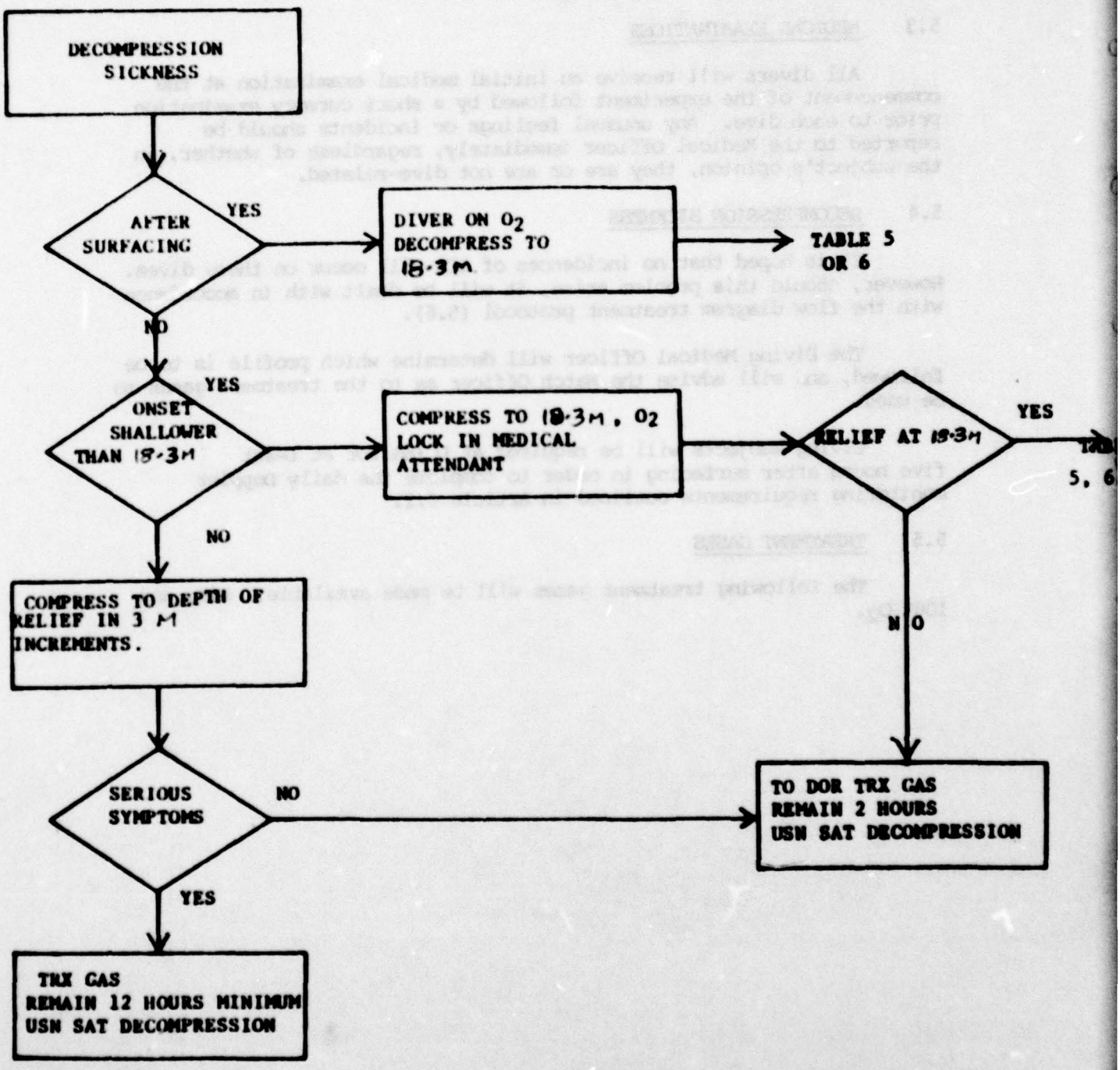
The Diving Medical Officer will determine which profile is to be followed, and will advise the Watch Officer as to the treatment gases to be used.

Diving subjects will be required at DCIEM for at least five hours after surfacing in order to complete the daily Doppler monitoring requirements outlined in Article 6.2.

5.5 TREATMENT GASES

The following treatment gases will be made available: Air, and 100% O_2.

5.6 DECOMPRESSION SICKNESS TREATMENT PROTOCOL



5.7 DIVING SUBJECTS - REPORTING DECOMPRESSION AILMENTS

All diving subjects should be fully conversant with the routine for reporting any symptoms of diving ailments either during the dive or after surfacing. The necessity of reporting any symptoms at the earliest opportunity is also stressed; therefore, it is imperative that all diving subjects fully understand the recall system and comply with the same. The reporting procedure is outlined for two distinct situations:

a. During Working Hours

Any diving subject who has the slightest inclination that he may be suffering from a diving ailment should report to a staff member of CEDD, preferably the Operations or Diving Medical Officer, who will ensure that a suitable follow-up action is initiated; and

b. During Silent/Non-Working Hours

Any diving subject suspecting possible diving ailments is to inform the Duty Diver immediately, giving his location and method of travel to the CEDD facilities. The ailing subject should attempt to have someone accompany him to the chamber area in case more serious complications occur. The Duty Diver will initiate action to have the appropriate personnel recalled to handle the situation.

The Duty Diver is available through the CFB Toronto (633-6200) telephone operator or at his home as listed in the Daily Bends Watch List.

The Medical Officer is available through the CFB Toronto (633-6200) telephone operator or at his home as listed in the Daily Bends Watch List.

PART VI

SCIENTIFIC PROCEDURES

6.1.1 INTRODUCTION

A brief history of the XDC-2 Computer is contained in part I of the Protocol.

6.1.2 PROCEDURE

The operation and procedures to be followed with the XDC-2's are contained in Annex D.

6.1.3 MONITORING

This will be carried out by technicians of the Diving Division. The computer monitoring technician will carry out the monitoring as described in article 3.3 and as amplified in the pertinent annex.

6.1.4 DIVE TIMES FOR XDC-2 COMPUTER

The following table depicts the Dive Serial letter as described in article 2.6 and is to be used in conjunction with Annex E.

DIVE SERIAL	DEPTH (msw)	BOTTOM[1] TIME (min)	ASCENT[2] TIME TO 3 msw(min)	STOP TIME AT 3msw (min)	TOTAL ASCENT TIME (min)	TOTAL TIME OF DIVE (min)
A	36	30	14	15	31	61
B	36	40	18	20	40	80
C	36	50	22	31	55	105
D	45	20	15	14	31	51
E	45	25	19	16	37	62
F	45	30	22	21	45	75
G	54	15	16	13	31	46
H	54	20	22	16	40	60
J	54	25	27	24	53	78

1. Descent time to bottom is included in bottom time. Descent rate varies from 18 msw/min to 8.8 msw/min at 54 msw for dive chamber and transfer sphere combination. Descent time to 36 msw is 2.5 min.; to 45 msw is 3.3 min.; to 54 msw is 4.2 min.

2. Ascent time is initially at 18 msw/min to 40 msw and is then determined by the maximum venting capability of the dive chamber/ transfer sphere combination.

2. Ascent time is initially at 18 MSW/min. to 40 MSW and is then determined by the maximum venting capability of the dive chamber/ transfer sphere combination.

6.1.5 DIGITAL DATA LOGGER

A Digital Data Logger (DDL-1) will be used in conjunction with the XDC-2 Decompression Computer for the purpose of data recording and validation of the performance of the Data Logger. The DDL-1 is capable of collecting data from up to four (4) XDC-2 units.

Each dive must be recorded separately on one magnetic tape per dive.

The Data Logger will be operated by WO Janes or Sgt Stewart who will also manually record the data in order to perform a back-up in accordance with DDL-1 validation.

6.2 ULTRASONIC MONITORING

1. Procedure

At each monitoring session, the diver is monitored for approximately 30 s after he has been standing at ease for at least 2 minutes; then for a further 30 s during and following a deep knee bend by the diver.

The monitoring technique involves:

a. adding a gel to the probe;

b. positioning the probe on the chest;

c. listening to the signal with headsets;

d. recording the signal on a tape recorder;

The instrument used will be the French DUG portable unit.

Before the dive programme begins, an initial training session of 15 - 30 minutes is required for each diver, with the assistance of feedback via a headset, to teach him how to place the probe while he is in the DDF.

For each dive there will be two DUG's in use and two operators who will alternately monitor each diver. Visual observation by the operator of the diver in the DDF as he positions the probe on his chest is required.

Immediately before each dive, a reference monitoring session is held with each diver.

One monitoring session is held for each dry diver while he is at bottom.

After the beginning of decompression, a monitoring session is held for each dry diver every 10 minutes for 3.5 hours and every 30 minutes for the next 1.5 hours. Monitoring is delayed until the end of decompression for the wet divers.

Mr. G. Masurel from CERTSM, Toulon, France will be invited to participate in the ultrasonic monitoring programme. Two DCIEM technicians should be available for training and assistance during the dive programme. The training will involve 5 half-days prior to commencement of diving.

2. Results

The time of maximum bubble activity is expected to occur approximately 1.5 hours following the end of decompression.

The bubble results will be expressed as maximum bubble grade (viz the KM code) on a scale from 0 to 4 and as an index of severity which integrates all the bubble information.

The current working criterion for acceptability of a dive is that grade 3 bubbles at rest occur only rarely (10% of man dives).

The dive programme will involve two wet, working divers and several dry non-working divers. Since bubbles are expected to be found in most of the divers following each dive which closely follows the computer profile, correlation studies should be possible between the two classes of divers using bubble activity as the criterion. This involves careful planning of the daily diving schedule for the divers to optimize the statistical accuracy of the correlation studies. An assessment of the correlation between dry non-working diver results and results from wet working divers would enhance the value of the considerable banks of data accumulated for dry non-working divers.

Correlation studies between dry non-working divers and dry working divers would be desirable. This would separate the importance of wet versus dry and work versus non-work in the correlation studies described above. Among the factors such as work level, temperature, level of anxiety, etc. that affect the decompression of divers, work likely has the greatest effect on blood flow and gas uptake in tissues and so work level should be the first factor investigated.

A long-range objective of ultrasonics research programmes is that bubble rate results (e.g. a maximum of grade 3 at rest and a maximum value on the index of severity), may replace the probability of bends as the primary criterion for development of decompression profiles. This is because the bubble results are generally an earlier and more sensitive index of decompression stress and because excessive bubbles should not be tolerated even in the absence of overt manifestations of decompression sickness. This may result in more conservative profiles. However, if divers have more confidence in the safety of profiles, they may follow them more closely with the net result that they decompress more safely without a time penalty.

6.3 UNDERWATER BICYCLE ERGOMETER

The underwater bicycle ergometer has been constructed using components of the electronically braked Collins Pedal Mode Ergometer. The pedal unit is housed in a water-tight acrylic housing, internally pressurized with a gas at a pressure 25-30 cmH_2O over chamber pressure by a demand regulator located 25 cm below the bottom of the ergometer box and an exhaust flapper valve located 30 cm below the box. The gas is continuously supplied from the BIBS system within the wet pot chamber via a one-way valve and a needle valve. The supply will be continuous until the water is dumped from the chamber. Therefore, it is important that the BIBS quick-connect joint is not disconnected at any time while the Ergometer remains submerged.

The ergometer is electronically controlled from a unit located outside the chamber. The workload will be pre-set to one level of 50 watts throughout the experiments. In order that the performed work level is maintained unaltered, subjects will have to pedal at a rate greater than 40 RPM which is the minimum RPM required to activate the feedback system. A remote tachometer, mounted on the handle bars and equipped with a warning signal light, provides the feedback information to the subject.

The ergometer will be kept operational throughout the evaluation by the Diving R&D Section. However, once it is pre-set for operation, it is expected that it will not require any adjustment; the experimenters should visually check that the pre-set work level does not change and that the diving subjects pedal at a sufficient rate. Any other problems/difficulties will be reported to the R&D Section for their attention.

2.11 DIVING SOP - WET SUBJECTS

This SOP is outlined to ensure that all inside diving subjects and outside DDF control staff conform to a safe and co-ordinated procedure during the conduct of diving operations in the wet diving chamber. It is divided into three segments and it is the responsibility of the Watch Officer to ensure that all checks have been completed in accordance with this procedure.

PRE-DIVE

a. Subjects

Both diving subjects will be responsible for reporting for the dive dressed in a suitable standard foam neoprene wet suit complete with suitable weight compensation to facilitate carrying out of their work tasking in the water section of the wet chamber.

b. Equipment Checks

Inside tenders and working divers are to ensure that the following checks on equipment are completed prior to dive commencement time:

(1) check that face and oral-nasal mask is properly attached to main frame of KMB-9's,

(2) Check for correct functioning of non-return valve by connecting emergency come home bottle to emergency gas supply valve. Open emergency supply valve and, while holding inlet of non-return valve in water, check for bubble flow,

(3) check that diving umbilicals are secured correctly to mask and diver's manifold. This to include computer pneumo hose and communications cable also,

(4) Adjust Tescom regulator to 145 psi above ambient,

(5) Ensure correct functioning of the following KMB apparatus:

(A) Free flow valve,

(B) Second stage regulator

(C) Purge Button

(D) Second stage regulator adjustment knob.

(6) check that come home bottle is charged to minimum of 1800 psi with first stage regulator and connecting hose properly

(7) check that communications are correct and functioning.

DIVE PROCEDURE

a. (Compression Phases)

Steps

(1) At the direction of topside control, both divers will don weight belts and emergency come home bottles,

(2) check that umbilical snaphook will be secured,

(3) Both divers will proceed over water barrier,

(4) Diving tender will shut off umbilical supply,

(5) Both divers check emergency come home system functioning correctly. Close emergency valve,

(6) Diving tenders open umbilical supply,

(7) Check Communications,

(8) Both divers will stand upright in water,

(9) Stand-by to pressurize,

(10) On "reaching bottom" both divers will don KMB masks,

(11) Check communications,

(12) Both divers will immerse and report status of equipment,

(13) As delegated, one diver will act as stand-by diver while the other diver will proceed under the barrier to the ergometer,

(14) Working diver will inform topside when he is in position on the ergometer and ready to commence work load

(15) Topside control direct diver will commence work load,

(16) At the end of 6-minute period topside will direct diver to cease work load,

(17) Topside will direct divers to change positions and repeat steps 13 to 16. This procedure will continue until completion of dive bottom time,

(18) On completion of bottom time, divers will assume a restful position but remain immersed in the water.

b. Decompression Phase

(1) Divers will be informed of start of decompression,

(2) Divers are to report to topside control any indications of possible decompression sickness,

(3) Dry diving subjects will commence monitoring via doppler equipment in accordance with Article 6.2. The doppler system will also be used to monitor the diving tender subjects. All doppler monitoring will continue until dive surfaces.

3. POST DIVE

a. On surfacing, as directed, divers will proceed over the barrier;

b. Tenders will assist in removing KMB masks and emergency come-home bottle.

c. Diver's wet suit wil be removed;

d. Doppler monitoring of wet subjects will commence;

e. Pressure on diving umbilicals will be drained;

f. All divers will proceed to CEDD lounge area for continuance of doppler monitoring.

4. DIVER EMERGENCY

Should a diver (wet subject) emergency develop during the course of the dive, the following sequence of events must be followed:

Loss of Breathing Media

a. Diver concerned will report same to topside;

b. Diver will activate emergency come-home system;

c. If it is the working diver, he should dismount the ergometer and proceed towards the barrier, pass underneath and stand clear of the water;

d. The stand-by diver should render assistance, if possible, being prepared to remove the working diver physically from beyond the barrier. When rendering assistance he should bear in mind the possible problem of umbilicals becoming entangled both his own and that of the diver in distress. The stand-by diver should endeavour to inform both the diving tenders and topside personnel of events as they occur;

e. Should the stand-by diver be the one to have an equipment malfunction, he simply shall stand up and remove his KMB mask to facilitate breathing. If this occurs, the working diver should immediately be instructed to proceed forward and underneath the barrier and to wait for the instructions; and

f. On the occurrence of a diving emergency, diving tenders are to inform topside personnel immediately and also summon the dry diving subjects to render any necessary aid or support.

5. DIVE ABORT PROCEDURE

It may be necessary or desirable to terminate a dive at any time should their be a DDF malfunction or a diving subject problem.

Should it become necessary to abort a dive, it will be declared by topside control; both wet divers will be ordered out of the water and equipment will be removed.

All subjects should be prepared to act as directed by topside control and respond accordingly.

2.12 BENDS WATCH ROUTINE

Duty Personnel

1. During the XDC-2 trial programme it will be necessary to maintain a "bends watch" to ensure twenty-four-hour coverage should any diving-related ailments occur.

2. A daily bends watch sheet (Annex C) will be maintained throughout the duration of the XDC-2 trial period; it will delegate the personnel required to be on a recall basis. Bends watches will commence at secure the day of diving and terminate at 0830 the following working day. On week-ends the watch will change daily at 0830.

3. The duty diver will be required to be at his home telephone at all times during the non-working hours to co-ordinate the location of personnel on recall. It will be the responsibility of all personnel on recall to keep the duty diver informed of where they can be immediately contacted by telephone.

DIVING SUBJECTS - REPORTING DECOMPRESSION AILMENTS

All diving subjects should be fully conversant with the routine for reporting any symptoms of diving ailments either during the dive or after surfacing. The necessity of reporting any symptoms at the earliest opportunity is also stressed; therefore, it is imperative that all diving subjects fully understand the recall system and comply with the same. The reporting procedure is outlined for two distinct situations:

a. During Working Hours

Any diving subject who has the slightest indication that he may be suffering from a diving ailment should report to a staff member of CEDD, preferably the Operations or Diving Medical Officer, who will ensure that a suitable follow-up action is initiated; and

b. During Silent/Non-Working Hours

Any diving subject suspecting possible diving ailments is to inform the Duty Diver immediately, giving his location and method of travel to the CEDD facilities. The ailing subject should attempt to have someone accompany him to the chamber area in case more serious complications occur. The Duty Diver will initiate action to have the appropriate personnel recalled to handle the situation.

ANNEX C

DATE

2.13 DUTY BENDS WATCH LIST

	NAME	TELEPHONE
DUTY OFFICER		
DUTY DIVER		
MEDICAL OFFICER		
DDF WATCH OFFICER		
DDF CHIEF CONTROLLER		
DDF ASSISTANT CONTROLLER		
DDF ENVIRONMENTAL LOOP MONITOR		
DDF TECHNICAL		
DCIEM ENGINEER		
XDC-2 TECHNICIAN		
DIVERS		

XDC-2 USE AND PROCEDURES

1. Operating Procedures

The procedures and responsibilities defined in the following text are for the exclusive purpose of the Phase I, XDC-2 Validation Dives 0-54 MSW, and are not to be construed as the general operating procedures for the computers.

Prior to the start date, the staff of the Decompression Computer and Electronics Laboratory (DCEL) in co-operation with Mr. R. Nishi of the Biophysics Section will set-up and ensure the proper operation of four (4) XDC-2 decompression computers. These computers will be positioned to the left of the Manual Control Console and above the television monitors. This position was chosen to allow easy viewing for the console operator, computer technician as well as the Watch Officer. A combination of electrical and pneumatic feeds will be used with the computers.

The four decompression computers will monitor pressures at the following stations within the DDF: one at the transfer sphere, one at the dry part of the dive chamber, and two connected to the umbilical cords of the divers. The monitoring capability will be provided by a combination of transducers located at the computers and the chamber, resulting in a combination of electrical and pneumatic feeds to the computers. The Biotechnology Laboratory will install the transducers located in the chamber and the electrical feeds to the XDC-2's.

A Digital Data Logger (DDL-1) will be used for collecting data from all four XDC-2 computers. This application of the DDL-1 will provide a test of its capabilities and validation of its performance. Each dive sequence must be recorded separately on one magnetic tape per dive. The DDL-1 will be interfaced with a teleprinter providing a visual validation of the DDL-1 performance. The Data Logger and the teleprinter will be positioned behind the console operator and beside the communications control panel. This will also be the computer technician's normal position after the pressurization has commenced.

The staff of the DCEL will perform the usual manual recording of the dive information obtained from the computers, at least during the first few dives. If data logged and printed automatically appear to be reliable, the back-up manual logging may be suspended for the subsequent dives.

The logger and the computers will be switched on at least thirty (30) minutes prior to the pressurization time in order to provide a sufficient warm-up time for the electronic equipment. The present configuration of the data logger requires that start-up times on the XDC-2 computers be staggered in order to ensure that no data are lost owing to more than one XDC-2's attempting to feed in at the same instant. This staggered start time will cause the figures displayed on

the various computers to change over at different times; the difference will be no more than two (2) seconds. A five (5) minute warning from the Watch Officer before the commencement of the pressurization is required by the staff manning the computers. This warning will provide the time to re-start the computers or change connections, if required.

2. Emergency Procedure

In the event of an emergency, the actual sequence of events will depend to a large extent on the type of emergency and the orders of the Watch Officer. However, certain general cases may be addressed at this stage:

a. Power Failure

The XDC-2 computer will switch over automatically to the internal battery power supply and therefore no further action is required; the DDL-1 does not have any internal power supply and therefore a manual log of the dive data must be maintained to cover the period of the power failure;

b. XDC-2 Malfunction

The most common malfunction will probably be a blockage in the pneumatic feed lines to the XDC-2; this condition will be quite obvious as the affected computer will read much shallower than the others on the depth gauge; in this case, the malfunctioning computer will be ignored and readings will be taken only from the other computers; the blockage should be thoroughly investigated before the next dive and remedied if possible;

c. Fire, etc.

Emergencies such as fire in the chambers could cause damage to the penetrator or cause a blockage of water in the penetrator; in this case, computer tables will be available and will be used to complete the decompression.

3. Responsibilities of the Computer Technician During the Dives

a. ensure that a good start is made and that approximately 30 minutes warm-up time is allowed for the decompression computers;

b. ensure that inputs from all four (4) XDC-2 computers to the DDL-1 are connected;

c. ensure that the DDL-1 is recording on tape and

has correct teletype output;

d. Inform the Watch Officer which computer is to be followed and any reason for a change. NORMALLY THIS WILL BE THE COMPUTER SHOWING THE DEEPEST SAFE DEPTH;

e. maintain a written record of the dives;

f. maintain a written record of breakdowns or abnormal readings of the computers;

g. ensure that all computers are operating satisfactorily and enter any unusual occurrences on the DDL-1 tape record.

ANNEX E

DCIEM DECOMPRESSION PROFILE (METRIC) - COMPRESSED AIR
36 METRES OF SEAWATER FOR 30 MINUTES
DESCENT AND INITIAL ASCENT RATES SET FOR DIVE CHAMBER AND TRANSFER SPHERE COMBINATION
CONTINUOUS ASCENT WITH HOLD AT 3 METRES

TIME (MIN)	DEPTH (MSW)	DEPTH (BAR)	K	DSA (MSW)
0.0	0.0	0.00	1	-5.81
1.0	16.7	1.68	1	-5.61
2.0	30.7	3.09	1	-5.04
2.5	36.0	3.62	1	-4.62
5.0	36.0	3.62	1	-2.57
10.0	36.0	3.62	1	0.76
15.0	36.0	3.62	1	3.29
20.0	36.0	3.62	1	5.21
25.0	36.0	3.62	1	6.69
30.0	36.0	3.62	1	7.85
31.0	22.4	2.25	1	7.81
32.0	15.5	1.56	1	7.51
33.0	11.2	1.12	1	7.11
34.0	7.8	0.78	1	6.66
34.5	6.4	0.65	1	6.42
35.0	6.2	0.62	1	6.18
36.0	5.7	0.58	1	5.73
37.0	5.3	0.53	1	5.30
38.0	4.9	0.49	1	4.89
39.0	4.5	0.45	1	4.50
40.0	4.1	0.42	1	4.14
41.0	3.8	0.38	1	3.79
42.0	3.5	0.35	1	3.45
43.0	3.1	0.32	1	3.13
44.0	3.0	0.30	1	2.83
STOP TIME 15				
50.0	3.0	0.30	1	1.37
59.0	3.0	0.30	1	-0.07
60.0	1.4	0.14	1	-0.21
61.0	0.2	0.02	1	-0.37
61.3	0.0	0.00	1	-0.42

JUNE 20, 1979

DCIEM DECOMPRESSION PROFILE (METRIC) - COMPRESSED AIR
36 METRES OF SEAWATER FOR 40 MINUTES
DESCENT AND INITIAL ASCENT RATES SET FOR DIVE CHAMBER AND TRANSFER SPHERE COMBINATION
CONTINUOUS ASCENT WITH HOLD AT 3 METRES

TIME (MIN)	DEPTH (MSW)	DEPTH (BAR)	K	DSA (MSW)
0.0	0.0	0.00	1	-5.81
1.0	16.7	1.68	1	-5.61
2.0	30.7	3.09	1	-5.04
2.5	36.0	3.62	1	-4.62
5.0	36.0	3.62	1	-2.57
10.0	36.0	3.62	1	0.76
15.0	36.0	3.62	1	3.29
20.0	36.0	3.62	1	5.21
25.0	36.0	3.62	1	6.69
30.0	36.0	3.62	1	7.85
35.0	36.0	3.62	1	8.78
40.0	36.0	3.62	1	9.53
41.0	22.4	2.25	1	9.43
42.0	15.5	1.56	1	9.06
43.0	11.2	1.12	1	8.61
43.9	8.2	0.82	1	8.16
44.0	8.1	0.81	1	8.10
45.0	7.6	0.76	1	7.61
46.0	7.1	0.72	1	7.13
47.0	6.7	0.67	1	6.69
48.0	6.3	0.63	1	6.27
49.0	5.9	0.59	1	5.86
50.0	5.5	0.55	1	5.48
51.0	5.1	0.51	1	5.12
52.0	4.8	0.48	1	4.77
53.0	4.4	0.45	1	4.44
54.0	4.1	0.41	1	4.12
55.0	3.8	0.38	1	3.82
56.0	3.5	0.35	1	3.52
57.0	3.2	0.33	1	3.25
58.0	3.0	0.30	1	2.98
STOP TIME 20				
60.0	3.0	0.30	1	2.49
70.0	3.0	0.30	1	0.69
78.0	3.0	0.30	2	-0.04
79.0	1.4	0.14	2	-0.10
80.0	0.2	0.02	2	-0.16
80.3	0.0	0.00	2	-0.17

JUNE 20, 1979

DCIEM DECOMPRESSION PROFILE (METRIC) - COMPRESSED AIR
36 METRES OF SEAWATER FOR 50 MINUTES
DESCENT AND INITIAL ASCENT RATES SET FOR DIVE CHAMBER
AND TRANSFER SPHERE COMBINATION
CONTINUOUS ASCENT WITH HOLD AT 3 METRES

TIME (MIN)	DEPTH (MSW)	DEPTH (BAR)	K	DSA (MSW)
0.0	0.0	0.00	1	-5.81
1.0	16.7	1.68	1	-5.61
2.0	30.7	3.09	1	-5.04
2.5	36.0	3.62	1	-4.62
5.0	36.0	3.62	1	-2.57
10.0	36.0	3.62	1	0.76
15.0	36.0	3.62	1	3.29
20.0	36.0	3.62	1	5.21
25.0	36.0	3.62	1	6.69
30.0	36.0	3.62	1	7.85
35.0	36.0	3.62	1	8.78
40.0	36.0	3.62	1	9.53
45.0	36.0	3.62	1	10.17
50.0	36.0	3.62	1	10.70
51.0	22.4	2.25	1	10.56
52.0	15.5	1.56	1	10.16
53.0	11.2	1.12	1	9.67
53.5	9.4	0.95	1	9.41
54.0	9.1	0.92	1	9.14
55.0	8.6	0.87	1	8.64
56.0	8.2	0.82	1	8.16
57.0	7.7	0.77	1	7.71
58.0	7.3	0.73	1	7.28
59.0	6.9	0.69	1	6.87
60.0	6.5	0.65	1	6.48
61.0	6.1	0.61	1	6.11
62.0	5.8	0.58	1	5.76
63.0	5.4	0.54	1	5.42
64.0	5.1	0.51	1	5.09
65.0	4.8	0.48	1	4.79
66.0	4.5	0.45	1	4.49
67.0	4.2	0.42	1	4.20
68.0	3.9	0.39	1	3.93
69.0	3.7	0.37	1	3.67
70.0	3.4	0.34	1	3.41
71.0	3.2	0.32	1	3.17
72.0	3.0	0.30	1	2.93
STOP TIME 31				
80.0	3.0	0.30	2	1.49
90.0	3.0	0.30	2	0.76
100.0	3.0	0.30	2	0.16
103.0	3.0	0.30	2	-0.00
104.0	1.4	0.14	2	-0.05
105.0	0.2	0.02	2	-0.10
105.3	0.0	0.00	2	-0.12

DCIEM DECOMPRESSION PROFILE (METRIC) - COMPRESSED AIR
45 METRES OF SEAWATER FOR 20 MINUTES
DESCENT AND INITIAL ASCENT RATES SET FOR DIVE CHAMBER AND TRANSFER SPHERE COMBINATION
CONTINUOUS ASCENT WITH HOLD AT 3 METRES

TIME (MIN)	DEPTH (MSW)	DEPTH (BAR)	K	DSA (MSW)
0.0	0.0	0.00	1	-5.81
1.0	16.7	1.68	1	-5.61
2.0	30.7	3.09	1	-5.04
3.0	42.6	4.28	1	-4.12
3.3	45.0	4.52	1	-3.78
5.0	45.0	4.52	1	-1.92
10.0	45.0	4.52	1	2.59
15.0	45.0	4.52	1	5.96
20.0	45.0	4.52	1	8.47
21.0	28.5	2.86	1	8.58
22.0	18.2	1.83	1	8.30
23.0	13.2	1.33	1	7.87
24.0	9.4	0.94	1	7.38
24.8	7.0	0.70	1	6.96
25.0	6.9	0.69	1	6.86
26.0	6.3	0.64	1	6.34
27.0	5.9	0.59	1	5.86
28.0	5.4	0.54	1	5.41
29.0	5.0	0.50	1	4.98
30.0	4.6	0.46	1	4.57
31.0	4.2	0.42	1	4.18
32.0	3.8	0.38	1	3.81
33.0	3.5	0.35	1	3.46
34.0	3.1	0.31	1	3.13
35.0	3.0	0.30	1	2.81
STOP TIME 14				
40.0	3.0	0.30	1	1.50
49.0	3.0	0.30	1	-0.06
50.0	1.4	0.14	1	-0.21
51.0	0.2	0.02	1	-0.38
51.3	0.0	0.00	1	-0.43

JUNE 20, 1979

DCIEM DECOMPRESSION PROFILE (METRIC) - COMPRESSED AIR
45 METRES OF SEAWATER FOR 25 MINUTES
DESCENT AND INITIAL ASCENT RATES SET FOR DIVE CHAMBER AND TRANSFER SPHERE COMBINATION
CONTINUOUS ASCENT WITH HOLD AT 3 METRES

TIME (MIN)	DEPTH (MSW)	DEPTH (BAR)	K	DSA (MSW)
0.0	0.0	0.00	1	-5.81
1.0	16.7	1.68	1	-5.61
2.0	30.7	3.09	1	-5.04
3.0	42.6	4.28	1	-4.12
3.3	45.0	4.52	1	-3.78
5.0	45.0	4.52	1	-1.92
10.0	45.0	4.52	1	2.59
15.0	45.0	4.52	1	5.96
20.0	45.0	4.52	1	8.47
25.0	45.0	4.52	1	10.38
26.0	28.5	2.86	1	10.39
27.0	18.2	1.83	1	10.02
28.0	13.2	1.33	1	9.51
29.0	9.4	0.94	1	8.94
29.2	8.8	0.89	1	8.82
30.0	8.4	0.84	1	8.36
31.0	7.8	0.79	1	7.82
32.0	7.3	0.73	1	7.30
33.0	6.8	0.69	1	6.82
34.0	6.4	0.64	1	6.36
35.0	5.9	0.60	1	5.92
36.0	5.5	0.55	1	5.51
37.0	5.1	0.51	1	5.12
38.0	4.7	0.48	1	4.74
39.0	4.4	0.44	1	4.39
40.0	4.0	0.41	1	4.05
41.0	3.7	0.37	1	3.73
42.0	3.4	0.34	1	3.42
43.0	3.1	0.31	1	3.12
44.0	3.0	0.30	1	2.84
STOP TIME 16				
50.0	3.0	0.30	1	1.46
60.0	3.0	0.30	1	-0.04
61.0	1.4	0.14	1	-0.18
62.0	0.2	0.02	1	-0.33
62.3	0.0	0.00	1	-0.38

JUNE 20, 1979

DCIEM DECOMPRESSION PROFILE (METRIC) - COMPRESSED AIR
45 METRES OF SEAWATER FOR 30 MINUTES
DESCENT AND INITIAL ASCENT RATES SET FOR DIVE CHAMBER
AND TRANSFER SPHERE COMBINATION
CONTINUOUS ASCENT WITH HOLD AT 3 METRES

TIME (MIN)	DEPTH (MSW)	DEPTH (BAR)	K	DSA (MSW)
0.0	0.0	0.00	1	-5.81
1.0	16.7	1.68	1	-5.61
2.0	30.7	3.09	1	-5.04
3.0	42.6	4.28	1	-4.12
3.3	45.0	4.52	1	-3.78
5.0	45.0	4.52	1	-1.92
10.0	45.0	4.52	1	2.59
15.0	45.0	4.52	1	5.96
20.0	45.0	4.52	1	8.47
25.0	45.0	4.52	1	10.38
30.0	45.0	4.52	1	11.85
31.0	28.5	2.86	1	11.79
32.0	18.2	1.83	1	11.36
33.0	13.2	1.33	1	10.78
33.8	10.3	1.03	1	10.29
34.0	10.2	1.02	1	10.16
35.0	9.6	0.96	1	9.56
36.0	9.0	0.90	1	9.00
37.0	8.5	0.85	1	8.46
38.0	8.0	0.80	1	7.96
39.0	7.5	0.75	1	7.48
40.0	7.0	0.71	1	7.03
41.0	6.6	0.66	1	6.60
42.0	6.2	0.62	1	6.19
43.0	5.8	0.58	1	5.80
44.0	5.4	0.55	1	5.43
45.0	5.1	0.51	1	5.08
46.0	4.7	0.48	1	4.74
47.0	4.4	0.44	1	4.42
48.0	4.1	0.41	1	4.11
49.0	3.8	0.38	1	3.81
50.0	3.5	0.35	1	3.53
51.0	3.3	0.33	1	3.25
52.0	3.0	0.30	1	2.99
STOP TIME 21				
60.0	3.0	0.30	1	1.34
70.0	3.0	0.30	2	0.17
73.0	3.0	0.30	2	-0.02
74.0	1.4	0.14	2	-0.08
75.0	0.2	0.02	2	-0.14
75.3	0.0	0.00	2	-0.16

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DCIEM DECOMPRESSION PROFILE (METRIC) - COMPRESSED AIR
54 METRES OF SEAWATER FOR 15 MINUTES
DESCENT AND INITIAL ASCENT RATES SET FOR DIVE CHAMBER
AND TRANSFER SPHERE COMBINATION
CONTINUOUS ASCENT WITH HOLD AT 3 METRES

TIME (MIN)	DEPTH (MSW)	DEPTH (BAR)	K	DSA (MSW)
0.0	0.0	0.00	1	-5.81
1.0	16.7	1.68	1	-5.61
2.0	30.7	3.09	1	-5.04
3.0	42.6	4.28	1	-4.12
4.0	52.6	5.28	1	-2.87
4.2	54.0	5.43	1	-2.58
5.0	54.0	5.43	1	-1.47
10.0	54.0	5.43	1	4.38
15.0	54.0	5.43	1	8.70
16.0	36.1	3.63	1	9.05
17.0	22.4	2.25	1	8.88
18.0	15.6	1.56	1	8.46
19.0	11.2	1.12	1	7.95
20.0	7.8	0.78	1	7.40
20.2	7.3	0.73	1	7.29
21.0	6.8	0.69	1	6.85
22.0	6.3	0.64	1	6.33
23.0	5.8	0.59	1	5.83
24.0	5.4	0.54	1	5.37
25.0	4.9	0.50	1	4.93
26.0	4.5	0.45	1	4.51
27.0	4.1	0.41	1	4.12
28.0	3.7	0.38	1	3.75
29.0	3.4	0.34	1	3.39
30.0	3.1	0.31	1	3.05
31.0	3.0	0.30	1	2.73
STOP TIME 13				
40.0	3.0	0.30	1	0.62
44.0	3.0	0.30	1	-0.02
45.0	1.4	0.14	1	-0.17
46.0	0.2	0.02	1	-0.35
46.3	0.0	0.00	1	-0.40

JUNE 20, 1979

DCIEM DECOMPRESSION PROFILE (METRIC) - COMPRESSED AIR
54 METRES OF SEAWATER FOR 20 MINUTES
DESCENT AND INITIAL ASCENT RATES SET FOR DIVE CHAMBER
AND TRANSFER SPHERE COMBINATION
CONTINUOUS ASCENT WITH HOLD AT 3 METRES

TIME (MIN)	DEPTH (MSW)	DEPTH (BAR)	K	DSA (MSW)
0.0	0.0	0.00	1	-5.81
1.0	16.7	1.68	1	-5.61
2.0	30.7	3.09	1	-5.04
3.0	42.6	4.28	1	-4.12
4.0	52.6	5.28	1	-2.87
4.2	54.0	5.43	1	-2.58
5.0	54.0	5.43	1	-1.47
10.0	54.0	5.43	1	4.38
15.0	54.0	5.43	1	8.70
20.0	54.0	5.43	1	11.87
21.0	36.1	3.63	1	12.04
22.0	22.4	2.25	1	11.69
23.0	15.6	1.56	1	11.11
24.0	11.2	1.12	1	10.47
24.3	10.3	1.03	1	10.26
25.0	9.8	0.99	1	9.81
26.0	9.2	0.92	1	9.18
27.0	8.6	0.86	1	8.60
28.0	8.0	0.81	1	8.05
29.0	7.5	0.76	1	7.53
30.0	7.0	0.71	1	7.04
31.0	6.6	0.66	1	6.57
32.0	6.1	0.62	1	6.13
33.0	5.7	0.57	1	5.71
34.0	5.3	0.53	1	5.32
35.0	4.9	0.50	1	4.94
36.0	4.6	0.46	1	4.58
37.0	4.2	0.43	1	4.24
38.0	3.9	0.39	1	3.91
39.0	3.6	0.36	1	3.60
40.0	3.3	0.33	1	3.30
41.0	3.0	0.30	1	3.01
42.0	3.0	0.30	1	2.73
STOP TIME 16				
50.0	3.0	0.30	1	1.05
58.0	3.0	0.30	1	-0.06
59.0	1.4	0.14	1	-0.19
60.0	0.2	0.02	1	-0.34
60.3	0.0	0.00	1	-0.39

JUNE 20, 1979

DCIEM DECOMPRESSION PROFILE (METRIC) - COMPRESSED AIR
54 METRES OF SEAWATER FOR 25 MINUTES
DESCENT AND INITIAL ASCENT RATES SET FOR DIVE CHAMBER
AND TRANSFER SPHERE COMBINATION
CONTINUOUS ASCENT WITH HOLD AT 3 METRES

TIME (MIN)	DEPTH (MSW)	DEPTH (BAR)	K	DSA (MSW)
0.0	0.0	0.00	1	-5.81
1.0	16.7	1.68	1	-5.61
2.0	30.7	3.09	1	-5.04
3.0	42.6	4.28	1	-4.12
4.0	52.6	5.28	1	-2.87
4.2	54.0	5.43	1	-2.58
5.0	54.0	5.43	1	-1.47
10.0	54.0	5.43	1	4.38
15.0	54.0	5.43	1	8.70
20.0	54.0	5.43	1	11.87
25.0	54.0	5.43	1	14.22
26.0	36.1	3.63	1	14.26
27.0	22.4	2.25	1	13.80
28.0	15.6	1.56	1	13.11
28.7	12.6	1.27	1	12.59
29.0	12.4	1.24	1	12.37
30.0	11.7	1.17	1	11.66
31.0	11.0	1.11	1	11.00
32.0	10.4	1.04	1	10.37
33.0	9.8	0.98	1	9.78
34.0	9.2	0.93	1	9.23
35.0	8.7	0.87	1	8.70
36.0	8.2	0.82	1	8.20
37.0	7.7	0.78	1	7.73
38.0	7.3	0.73	1	7.29
39.0	6.9	0.69	1	6.86
40.0	6.5	0.65	1	6.46
41.0	6.1	0.61	1	6.08
42.0	5.7	0.57	1	5.71
43.0	5.4	0.54	1	5.36
44.0	5.0	0.51	1	5.02
45.0	4.7	0.47	1	4.70
46.0	4.4	0.44	1	4.40
47.0	4.1	0.41	1	4.10
48.0	3.8	0.38	1	3.82
49.0	3.5	0.36	1	3.54
50.0	3.3	0.33	1	3.28
51.0	3.0	0.30	1	3.03
52.0	3.0	0.30	1	2.79
STOP TIME	24			
68.0	3.0	0.30	1	1.26
70.0	3.0	0.30	2	0.34
76.0	3.0	0.30	2	-0.03
77.0	1.4	0.14	2	-0.09
78.0	0.2	0.02	2	-0.15
78.3	0.0	0.00	2	0.17